Determination of aerodynamic damping coefficients of entry vehicles in transonic regime

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Oscillatory motion is a dynamic phenomenon experienced by space capsules upon re-entry to the Earth's atmosphere. This behavior needs to be well understood for specific geometries to avoid unstable flight. Proper characterization of aerodynamic damping for stability evaluation can allow drogue chute deployment at lower Mach number.
The purpose of this work is to characterise the steady and unsteady aerodynamic characteristics of entry vehicles in the range of Mach numbers from low speed to supersonic. We use the EXPERT vehicle for the test case. The aerodynamic derivatives have been determined in several wind tunnels over a wide range of velocity. Experiments have been first carried out using the forced oscillation technique in sting configuration.
Transversal rod axis has been used as support for the model in the transonic/ supersonic S1 wind tunnel at The von Karman Institute for Mach numbers going from 0.5 to 2. The static efforts have been measured and the dynamic behaviour has been investigated thanks to the two types of oscillations techniques, namely the free oscillations and the forced oscillations.
Finally, different post-processing methods used to extract the damping in pitch parameter have been compared. A significant difference between the different sets of results shows that the support is a very important parameter which can produce significant discrepancy. The sources of uncertainty and the effect of wake flow on dynamic stability are discussed in detail in this paper for free and forced oscillation technique and for the different supports. That shows that a deep analysis of the support interference is needed to improve the quality of the results.

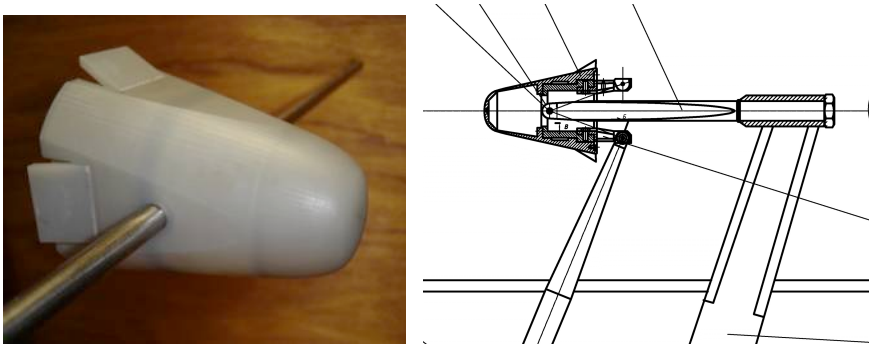

Figure 1 Expert model with transversal support (VKI) and sting support (SibNIA)